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FORT MONMOUTH, NJ 07703-5201

REPLY TO ATTENTION OF

23 MAR 1993

AMSEL-RD-AS-AR

MEMORANDUM FOR Defense Technical Information Center (DTIC), Receiving and Distribution Branch, RSR, Cameron Station, Alexandria, VA 22304-6145

SUBJECT: Inclusion of Papers in Data Base

1. It is requested that the enclosed paper entitled, "Soldier's Radio" (Enclosure 1), be included in your data base. Both the main body and Annex A have been cleared for public release as indicated by Enclosures 2 and 3.

2. In May 1993, a Small Business Innovative Research (SBIR) solicitation book will be released that includes a topic that specifically recommends that prospective offerors contact DTIC for any reports on Soldier's Radio.

3. Please take every measure to assure that this report is available to requestors by 1 May 1993. Please call Mr. James Schoening, DSN 992-0118, COM (908) 532-0118, upon receipt of this package to let him know it has been received and is being processed.

4. CECOM Bottom Line: THE SOLDIER.

3 Encls
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BRUCE C. MILLER
Director, Advanced Systems

SOLDIER'S RADIO

SUBMITTED TO:

MILCOM '92 - TACTICAL RADIO SESSION

FEBRUARY 14, 1992

SUBMITTED BY:

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SOLDIER'S RADIO

A. OVERVIEW

The need has been established by the U.S. Army to provide the future soldier with computing and communications capabilities. This will entail providing the individual soldier with a pocket-size computer as well as a communications device for the transmission of both voice and data. These programs are known as Soldier's Computer and Soldier's Radio, and will provide a truly exciting opportunity for the application of the latest in technology.

This paper addresses the Soldier's Radio and many of the unique constraints, issues, factors, and opportunities that will drive the design of this new system.

B. OBJECTIVE

Now is the time to influence the decisions and choices being made for this new military communications system. Technical input from industry, government, and academia is desired, and is the objective of this paper.

C. BACKGROUND

The Soldier's Radio [SR] is defined as a short range voice/data communications device for the individual soldier. It's primary use is by individuals in squads or small units, but may also be used to interconnect into local and wide area networks. It will be tightly integrated with the Soldier's Computer, which will be a pocket-size processor with a helmet-mounted display, hand held input device, plus a host of other peripheral devices including as Global Positioning System(GPS), digital compass, medical sensors, embedded training, digital maps, etc.

D. MULTI-MEDIA COMMUNICATIONS

Combining the capabilities of a computer with a data radio will provide the soldier with "Multi-media Communications." Various forms of communications (voice, voice-mail, e-mail, video, etc.) could be selected depending on factors such as available battery power, range, security, number of relays, availability of receiving party, nature of the message, and available bandwidth.

F. SCHEDULE AND ACQUISITION STRATEGY

Current plans call for the Soldier's Radio to be fielded as a subsystem of the The Enhanced Individual Soldier System(TEISS) in 1999. A Non-Developmental Item(NDI) acquisition strategy is the only feasible approach for various reasons. Time does not permit a full development cycle, funds may not be available for the development of a new radio, and commercial technology is advancing so rapidly that an NDI approach is the only way to keep pace with technology.

3. NETWORK ARCHITECTURE

Network architecture will be a critical consideration in developing the concept for the Soldier's Radio. The operation of the SR can be partitioned into two areas. The architecture required to provide intra-squad (soldier to soldier connectivity), and the architecture required to provide connectivity outside the unit (e.g., to upper and across echelons).

1. INTRA-SQUAD CONNECTIVITY

The basic radio communications architectures suitable for consideration for the SR intra-squad operations include the Net, Star, and Ring topologies.

The Net Topology, where everyone connects directly to everyone else, is the preferred mode for today's organic Army radio communications, because it is ideally matched to the needs of a military unit. The commander can talk directly to all subordinates at the same time, thus any order given is instantly coordinated. In the broadcast mode a net needs but one frequency. This identifying frequency allows an outside user to contact anyone inside that net. The disadvantage is that an enemy can identify units by the frequency they use.

Another consideration of using the net topology concerns broadcast versus private (one-to-one) communications modes. The classic net uses the broadcast mode. Privacy could be added by use of encryption schemes. However, encryption inhibits the instant coordination capabilities of the net. In the case of data transmission, headers can be used to assure that data messages get to their intended destination, but the data transmission protocol must be supportive of the existing classical net communications discipline (listen for the net to be free of traffic before transmitting).

The Star topology, where everyone connects directly to the leader only (Star), is the classical approach utilized in wire networks. Each member is connected to a central point which typically serves as a switching center, connecting members to each other on demand. A radio based star topology would operate in a similar fashion. However, the radio based star topology seems to offer more disadvantages than advantages. The unit leader is the center of the star and becomes the switching center. Only one connection can be activated at any one time. This is a cellular radio technique. Given the radio network is a single frequency system the system is very inflexible. The system is also vulnerable to loss of the central point. The star topology should not be considered as a potential solution to the Soldier's Radio problem.

The ring topology, where everyone connects to only two other members, creating a ring, has one serious flaw. If one SR fails or one connection is broken, the network goes down. It would also waste power by relaying messages many times around the ring, when a direct connection could be made.

2. EXTERNAL SQUAD CONNECTIVITY

Connectivity outside the unit can be achieved either by permitting each user to have direct access to other nets or through a central interface point.

In order for each SR to have direct contact with external units, the SR must be able to switch to the operating frequency, contain the appropriate protocols, and be in range of the adjacent unit. Operationally the SR must also have permission to enter another network. The integrated system control, e.g., the allocation of frequencies, the control of security keys, the minimization of traffic overload, the establishment of precedence, etc., becomes a large operational task.

The problems of providing individual connectivity of the SR to users outside its own network are substantially reduced if such connectivity is provided through a central point, namely, the unit leader. Doctrinally, the unit leader has command net connectivity with his adjacent units and their echelon commander (they share the same command net). Therefore he has the radio communications hardware/software to receive and transmit the required messages within that command net. If his unit is supplied with SRs, he will also need HW/SW which provides him connectivity with those SRs. Therefore, he will require two radio systems (can be in the same box), or one that is programmable to operate in either of the two echelons nets.

The benefits of the unit leader having a two radio net capability are fourfold: a. The unit leaders system can act as a repeater which provides connectivity from a given SR to or across echelons. b. The unit leader has control of the information/data which is leaving and entering his network. c. The architecture utilized within the SR network can be developed independently of the radio systems utilized in higher echelons. d. The design of the SR and its network can be optimized operational, technically, and cost effectively, and any technical and operational issues can be addressed almost independent of the impact of the higher echelon radios.

H. INFORMATION SECURITY

Information security [INFOSEC] is the protection of information against unauthorized disclosure, modification, or destruction. It has three major components: Communications Security [COMSEC] which is used to encrypt information to deny its authorized use; Transmission Security [TRANSEC] which is used to protect radio frequency emissions from jamming or detection; and Computer Security [COMPUSEC] which provides the means to protect information being handled by computers.

The SR would have the responsibility for providing the COMSEC and TRANSEC capabilities for the soldier's system. The Soldier's Computer would contain the required COMPUSEC.

I. OPERATIONAL FREQUENCY BANDS

Which frequency band should the Soldier's Radio operate in? The choice of frequency band of operation depends on analysis of a host of interrelationships between the various spectrum alternatives and the Army's operational and organizational requirements. Some of these are: propagation, radio density, separation and replication of frequencies and nets, connectivity requirements, throughput, voice/data requirements, compatibility, range, cost, and NDI availability.

The lowest frequency bands have the best propagation conditions and the largest ranges, but they also have severe frequency congestion, require larger antennas, and are bandwidth limited. The UHF and lower microwave frequency bands have larger bandwidth capabilities, require small antennas, but are limited to line-of-sight [LOS] propagation with some reduction in range in dense forests. However this is also the band receiving much attention in the commercial market where the needs for data networking are driving the development efforts. The Millimeter wave band which provides very high bandwidth capability, has received much interest by the military because of its covert capabilities. The potential problems with MMW propagation are foliage penetration, and range limitations during severe precipitation. Laser communications is being pursued by commercial interests and small efforts in DOD. Ultraviolet transmission, under study by the Marine Corps and being tracked by CECOM, is in the early stage of R&D and shows promise of providing short range non-line-of sight covert connectivity through an atmospheric scatter phenomena.

J. ADDITIONAL CONSIDERATIONS

A host of additional considerations are under evaluation by the Army:

1. Voice and data contention: How do they share the same channel? Should voice override data? Can voice be packetized and interleaved? Should voice be limited to intra-squad communications, with only data being permitted to interconnect with other networks?

2. Full Duplex: How and at what cost can this be achieved for intra-squad communications. How can group conversations be achieved?

3. Position/Location: Can the Soldier's Radio be used to help determine the relative location of members of a squad. Could directional antennas, signal strength, or signal delay, in conjunction with Global Positioning System(GPS), pedometers, or other devices be used to triangulate a soldier's position in relation to other members of his squad.

4. Internetworking: How will the Soldier's Radio interface with wider area networks?

5. Protocols: New protocols will certainly need to be developed that will address constraints such as power conservation, rapidly changing Line-Of-Sight, voice/data contention, etc.

6. Power Conservation: The weight and cost of batteries is one of the most important factors of this system. What techniques can be used to conserve power.

7. Retransmission Unit: Should unattended retransmission units also be fielded? They could extend range, provide gateways into other networks, save battery power for the soldier, and enhance connectivity where Line-Of-Sight is a problem.

8. Electronic Counter-Countermeasures(ECCM): Choices of ECCM include frequency hopping, spread spectrum, low probability of intercept, etc.

9. Antenna: Where should it be placed on the Soldier?

10. Density of Radio: What happens when 10,000 soldier from many different units assemble at an airfield and all want to use their radios?

K. CONCLUSION

The Soldier's Radio is a new and exciting application of communications technology. It holds the potential to revolutionize tactical military doctrine, but only if the latest in technology can effectively be integrated into a system that will be light, affordable, and functional. Now is the time for those with technical expertise in the many areas of communications technology to influence the decisions that are being made on this system. Such input is welcome by the U.S. Army.

See attached Annex A: Soldier C3

Annex A

SOLDIER COMMAND, CONTROL AND COMMUNICATIONS

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I. SOLDIER C^3

Soldier Command, Control and Communications is an umbrella program at the US Army Communications Electronics Command, which includes various efforts relating to the electronics and Command, Control, and Communications (C^3) capabilities of the individual soldier. It is comprised of the Soldier's Computer and Soldier's Radio Programs, as well as a host of related concepts still under development.

II. SOLDIER'S COMPUTER

The Soldier's Computer will consist of the following components:

A. POCKET SIZE COMPUTER

The target weight of the basic processor, including battery and basic peripherals is 1 lb., for infantry soldiers. The processor has not been chosen yet, but some of the major trade-offs will include capability, weight, cost, and power consumption. Higher speed microprocessors can run better software and more peripherals, but also consume more power, which adds to weight and cost.

B. DISPLAY

The visual output device could be mounted to the helmet or cap, to the wrist, or to the back of the pocket computer. There are two types of head-mounted displays:

1. A heads-up display reflects its image off goggles or a faceshield, which permits the soldier to look through the computer image and still see the real world. This has the advantage of not blocking any of the forward vision of the individual, but the disadvantages of being heavier, more expensive, and more confusing for the user.

2. An occluded display blocks a portion of the forward vision, but one could still drive a vehicle by positioning the device at a low angle, or work with his hands by positioning the display at a higher angle. Human factors tests need to be conducted to determine the user preferences of these two types of displays.

C. COMPUTER INPUT DEVICES

1. This could be a joystick or trackball mounted to the belt, to the pocket computer, or hand-held.

2. Voice recognition is another prime candidate for an input device, because it would permit hands-free input. It is likely that voice recognition will always need a backup device.

3. An in-the-ear microphone is currently being evaluated by CECOM. This device is less obtrusive

than a helmet-mounted boom microphone, and also cuts out virtually all ambient noise, since it picks up the vibrations of the users voice that travel through the bone structure of his head.

4. The future soldier will probably utilize a suite of input devices that he will choose based on his particular task and situation. It is predicted that some truly unique devices will find great utility for military applications.

D. POSITION/NAVIGATION (POS/NAV)

Global Positioning System (GPS) devices are downsizing very rapidly and could provide a partial POS/NAV solution for the soldier. Additional concepts are also being considered such as pedometers, minature accelerometers, and triangulation based on directional antennas and distance between Soldier's Radios.

E. Beyond these basic components, there are numerous other peripheral devices that could be integrated into the Soldier's Computer including:

1. Medical sensors that could monitor a soldier's medical status in combat. The output could be fed back to the soldier so that he could pace himself, as well as reported up the chain of command so that each level of command could see a rolled-up summary of the medical status of subordinate units.

2. Audio sensors could provide the soldier with situation awareness beyond his own natural capabilities.

3. Video Imagery: The soldier could snap a digital image with a camera or night vision device and transmit it to his squad leader. This would give the squad leader the ability to see what his soldiers see.

III. SOLDIER'S RADIO

The Soldier's Radio will be a person communications device which will transmit bo voice and data. While its primary purpose will for communications within small units, it will al have the capability to interconnect with the oth data networks planned for the future battlefield. Th Internetworking will extend the range of the rad and increase its utilization. CECOM is curren performing a study on the Soldier's Radio to ident all of the technical approaches which have potent for meeting this requirement. As part of this stu we will be working very closely with the us community to start trading off the advantages a disadvantages of each technical approach.

While the aforementioned study is far from comple certain conclusions are beginning to crystallize. Th network architecture whithin squads will likely be Net Topology, where each radio attempts to conne directly to each other radio in the unit. This w provide the greatest chance of maintaining squa wide connectivity in varying terrain. Connecti outside the squad will probably be through a cent node, and may be limited to data only. The Soldie Radio will probably end up being a card embedded the Soldier's Computer and not a stand alone syste Both the radio and computer will cartainly acquired as a Non-Developmental Item (NDI), thou certain peripherals such as antennas may need to developed by the Army.

The choice of a frequency band has not been made, b will require the consideration of many facto

including propagation, radio density, separation and replication of frequencies and nets, connectivity requirements, throughput, voice/data requirements, compatibilty, range, cost, and NDI availability.

Also under study and not yet determined are the appropriate levels of Information Security (INFOSEC), Communications Security (COMSEC), Transmission Security (TRANSEC), and Computer Security (COMPUSEC).

A host of additional considerations are under study including voice/data contention, full duplex operation, internetworking, new protocols, power conservation techniques, unmanned retransmission units, Electronic Counter-Countermeasures (ECCM), antenna design and location on the soldier, and the problem of high densities of Soldier's Radios on the future battlefield.

IV. APPLICATIONS OF SOLDIER C^3

The number of applications that can be derived from Soldier C3 are limited only by one's imagination. This section will cover some of these applications, with an emphasis on those users that relate to Command-on-the-Move.

A. BATTLEFIELD STATUS

"Seeing" the battlefield has always been vitally important to all echelons of battlefield command. Soldier C3 will permit even the individual soldier to view a map depicting information such as friendly and enemy positions or contaminated areas. A team of soldiers could view the same map while receiving commands or discussing strategy, and could do so while marching or riding in an armored vehicle.

The soldier could also become a source of battlefield information. He could report enemy movements, terrain information, or other forms of data. He could be a passive platform for various sensors that would collect and forward data without his knowledge. For example, his audio sensor might sense an enemy helicopter that the soldier himself need not be concerned with.

This same information would both increase lethality and decrease fratricide. It would also increase the speed at which infantry squads could safely take new ground.

B. MULTI-MEDIA COMMUNICATIONS

The current mode of communications within the squad consists of voice and hand signals. The Soldier's Computer and Radio will provide various other means of communications which will have advantages in many situations

Voice radio will permit soldiers to spread further apart, while still retaining the ability to communicate and function as a team. Text messages could be input into the computer and then delivered by the network for later review. Voice mail will permit a verbal message to be recorded and delivered by the network. For preformatted messages, such as a call-for-fire report, the computer could fill in many of the blanks. Digital photographs will permit a soldier to show his commander what he sees.

Each of these means of communication has certain advantages based on factors such as the available bandwidth, or the types of information that need to be transmitted. Multimedia communictions, at the soldier level, will bring us closer to the ultimate goal of a real-time battlefield information system.

C. VEHICULAR DISPLAY

Many military systems such as tanks either have, or will have, computerized battle stations, which should work fine when the operator is sitting right at them. A pocket computer will permit the soldier to move away from his primary station and still maintain some level of interaction with the on-board computer. If for some reason the soldier is cut off completely from the system, he could still retain some degree of functionality.

D. ELECTRONIC NOTEBOOKS

Many soldiers enter into battle carrying large amounts of information in the form of paper-filled notebooks and small manuals. This trend can only increase as military warfare and equipment become more complex, and as soldiers need to be prepared to deploy anywhere in the world. Electronic notebooks, similar to the palmtop computers coming on the market, could be fielded in the next few years and could pave the way for the more complex Soldier C3 applications as discussed in this paper.

E. ADDITIONAL APPLICATIONS

1. Electronic Technical Manuals: U.S. Army policy already requires that technical manuals be developed in electronic format for new weapon systems. This maintenance software could be run on a belt-mounted computer with a head-mounted display and voice-recognition input system, which would provide the maintenance soldier with a fully portable hands-free reference tool. This is an application that could be fielded within 3-5 years.

2. Embedded Training: As the battlefield and its equipment become increasingly complex, a new mode of training soldiers will be needed. One solution would be to equip the soldier with the ability to take training when and where it is needed. This embedded training has the potential to substantially increase a soldier's "virtual" knowledge.

3. Fire Control/Lethality: The Soldier's Computer, in conjunction with a thermal weapon sight, could aid the soldier in detection, acquisition, recognition, and engagement of enemy targets. Future improvements in lethality may have less to do with the weapon and more to do with the computer software.

V. CONCLUSION

U.S. aircraft, ships, and armored vehicles are the best in the world, and are so to a large part because of their advanced electronics and C3 capabilities. Advances in technology will now let us extend these capabilities to the individual soldier. Let it be hoped that the Soldier System can command the attention and the resources that will be needed to make this potential a reality.

AMSEL-EA-PA 10 Sept 1992

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3. CECOM Bottom Line: THE SOLDIER.

Marjorie Koch
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